driver of profitability, is not sufficient to measure the attractiveness of a given build; rather, the best measure of profitability is the net present value (NPV) of a build. This gap to profitability in unserved areas is called the Broadband Availability Gap in the NBP; throughout this paper, we will refer to this financial measure as the Investment Gap.

- **Investment decisions are made on the incremental value they generate.** While firms seek to maximize their overall profitability, investment decisions are evaluated based on the incremental value they provide. In some instances, existing assets reduce the costs of deployment in a given area. The profitability of any build needs to reflect these potential savings, while including only incremental revenue associated with the new network build-out.
- **Capturing the local (dis-)economies of scale that drive local profitability requires granular calculations of costs and revenues.** Multiple effects, dependent on local conditions, drive up the cost of providing service in areas that currently lack broadband: Lower (linear) densities and longer distances drive up the cost of construction, while providing fewer customers over whom to amortize costs. At the same time, lower-port-count electronics have higher costs per port. In addition, these lower densities also mean there is less revenue available per mile of outside plant or per covered area.
- **Network-deployment decisions reflect service-area economies of scale.** Telecom networks are designed to provide service over significant distances, often larger than five miles. In addition, carriers need to have sufficient scale, in network operations and support, to provide service efficiently in that local area or market. Given the importance of reach and the value of efficient operations, it can be difficult to evaluate the profitability of an area that is smaller than a local service area.
- **Technologies must be commercially deployable to be considered part of the solution set.** Though the economic model is forward-looking and technologies continue to evolve, the model only includes technologies that have been shown to be capable of providing carrier-class broadband. While some wireless 4G technologies arguably have not yet met this threshold, successful market tests and public commitments from carriers to their deployment provide some assurance that they will be capable of providing serviee.

Implicit within the $23.5 billion gap are a number of key decisions about how to use the model. These decisions reflect

Exhibit A: Approach to Determining the Availability Gap[4]

Availability

Number of unserved and their proximity to current broadband infrastructure

Current state
- HFC, telco and wireless availability calculated independently
- Used best available data from commercial and government sources
- Filled data gaps with a statistical model

Future state
- Based on public announcements

7.0 million unserved homes

Funding shortfall

Funding required to induce operators to deploy ubiquitous broadband

Key principles
- NPV analysis
- Incremental economics
- Sufficiently granular
- Economies of scale
- Technologically conservative

Key decisions
- Fund only one network
- Market based disbursement
- Terrestrial coverage for all
- Account for 4G build out
- Proven use cases

$23.5 billion availability gap

beliefs about the role of government support and the evolution of service in markets that currently lack broadband. In short, these decisions, along with the assumptions that follow, describe how we used the model to create the $23.5 billion base case.

- **Fund only one network in each currently unserved geographic area.** The focus of this analysis is on areas where not even one network can operate profitably. In order to limit the amount of public funds being provided to private network operators, the base case includes the gap for funding only one network.
- **Capture likely effects of disbursement mechanisms on support levels.** Decisions about how to disburse broadband-support funds will affect the size of the gap. Market-based mechanisms, which may help limit the level of government support in competitive markets, may not lead to the lowest possible Investment Gap in areas currently unserved by broadband—areas where it is difficult for even one service provider to operate profitably.
- **Focus on terrestrial solutions, but not to the exclusion of satellite-based service.** Satellite-based service has some clear advantages relative to terrestrial service for the most remote, highest-gap homes: near-ubiquity in service footprint and a cost structure not influenced by low densities. However, satellite service has limited capacity that may be inadequate to serve all consumers in areas where it is the lowest-cost technology. Uncertainty about the number of unserved who can receive satellite-based broadband, and about the impact of the disbursement mechanisms both on where satellite ultimately provides service and the size of the Investment Gap, all lead us to not explicitly include satellite in the base-case calculation.
- **Support any technology that meets the network requirements.** Broadband technologies are evolving rapidly, and where service providers are able to operate networks profitably, the market determines which technologies "win." Given that, there appears to be little-to-no benefit to pick technology winners and losers in areas that currently lack broadband. Therefore, the base case includes any technology capable of providing service that meets the National Broadband Availability Target to a significant fraction of the unserved.
- **Provide support for networks that deliver proven use cases, not for future-proof build-outs.** While end-users are likely to demand more speed over time, the evolution of that demand is uncertain. Given current trends, building a future-proof network immediately is likely more expensive than paying for future upgrades.

Also implicit in the $23.5 billion gap are a number of major assumptions. In some sense, every input for the costs of network hardware or for the lifetime of each piece of electronics is an assumption that can drive the size of the Investment Gap. The focus here is on those selected assumptions that may have a disproportionately large impact on the gap or may be particularly controversial. By their nature, assumptions are subject to disagreement; Chapter 3 includes an estimate of the impact on the gap for different assumptions in each case.

- Broadband service requires 4 Mbps downstream and 1 Mbps upstream access-network service.
- The take rate for broadband in unserved areas will be comparable to the take rate in served areas with similar demographics.
- The average revenue per product or bundle will evolve slowly over time.
- In wireless networks, propagation loss due to terrain is a major driver of cost that can be estimated by choosing appropriate cell sizes for different types of terrain and different frequency bands.
- The cost of providing fixed wireless broadband service is directly proportional to the fraction of traffic on the wireless network from fixed service.
- Disbursements will be taxed as regular income just as current USF disbursements are taxed.
- Large service providers' current operating expenses provide a proxy for the operating expenses associated with providing broadband service in currently unserved areas.

These principles, decisions and assumptions are discussed in detail in Chapter 3.

In addition to the key assumptions above, there are numerous other assumptions that we made for each broadband technology we examined. In order to accurately model each technology, we had to understand both the technical capabilities and the economic drivers; a description of our treatment of each technology is provided in Chapter 4.

In addition to this technical paper, there is supplementary documentation describing our analysis and methods including CostQuest Model Documentation: Technical documentation of how the model is constructed, including more detail about the statistical model used to estimate availability and network infrastructure in areas where no data are available.

ENDNOTES

1 American Recovery and Reinvestment Act of 2009, Pub.L. No. 111-5, § 6001(k)(2)(D), 123 Stat. 115, 516 (2009) (Recovery Act).

2 Note the figure differs slightly from Exhibit 8-B of the first printing of the National Broadband Plan (NBP). While the gap remains $24 billion, the data in this paper are updated since the release of the NBP. future releases of the NBP will include these updated data.

3 As a threshold matter, the level of service to be supported must be set. This service is the National Broadband Availability Target which specifies downstream speeds of at least 4 Mbps and upstream speeds of at least 1 Mbps. Support for this target is discussed briefly in Section 4 and in detail in the Omnibus Broadband Initiative's (OBI) technical paper entitled Broadband Performance (forthcoming).

4 Homes are technically housing units. Housing units are distinct from households "A housing unit is a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters." In contrast, "A household includes all the persons who occupy a housing unit. . . . The occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated persons who share living arrangements." There are 130.1 million housing units and 118.0 million households in the United States. U.S Census Bureau, Households, Persons Per Household, and Households with Individuals Under 18 Years, 2000, http://quickfacts.census.gov/qfd/meta/long_71061.htm (last visited Mar. 7, 2010).

1. THE INVESTMENT GAP

Our analysis indicates that there are 7 million housing units (HUs) without access to terrestrial broadband infrastructure capable of meeting the National Broadband Availability Target of 4 Mbps download and 1 Mbps upload. Because the total costs of providing broadband service to those 7 million HUs exceed the revenues expected from providing service, it is unlikely that private capital will fund infrastructure capable of delivering broadband that meets the target.

We calculate the amount of support required to provide 100% coverage to the unserved consistent with the availability target to be $23.5 billion. As shown in Exhibit 1-A, the $23.5 billion gap is the net shortfall, including initial capital expenditures (capex), ongoing costs and revenue associated with providing service across the life of the asset.

Ongoing costs comprise ongoing capex, network operating expenses and selling, general and administrative expenses; the present values of these costs are shown in Exhibit 1-B.

Costs and the gap vary dramatically with population density, with the least densely populated areas accounting for a disproportionate share of the gap (see Exhibit 1-C). As noted in the NBP, and discussed more fully in the *Satellite* portion of Chapter 4, the highest-gap 250,000 housing units account for $13.4 billion of the total $23.5 billion investment gap.

In fact, deployment costs and the gap are driven largely by the density of the unserved, as will be discussed here and in Chapter 2 (see, for example, Exhibits 1-F and 2-D). Therefore, satellite-based broadband, which can provide service to almost any subscriber regardless of location and at roughly the same cost, could be an attractive part of the overall solution.

We rely on these results to represent an aggregate, nationwide figure. We are more cautious with results in specific geographies because the estimates of the availability of broadband capable networks are in part based on a statistical model (see Chapter 2 for more detail). When examined at a very granular level, the availability model will sometimes overestimate and sometimes underestimate service levels, but should tend to balance out when aggregated to larger geographic areas. In the maps throughout this section we aggregate outputs to the county, but data should still be considered only directionally accurate. Further analysis and improved source data would be required to refine estimates for particular geographies.

The map in Exhibit 1-D presents the Investment Gap for each county in the country. The gap in each county is calculated by adding the gap of all census blocks in that county. Since most counties have at least some census blocks with a net present value (NPV) gap, most counties have an NPV gap. Census blocks with a positive NPV (i.e., blocks where the gap is negative) offset losses in census blocks that are NPV negative. Thus, counties can have no gap if they are currently fully served (i.e., have no unserved), or if the total NPV in the county is positive. Note that dark blue counties have a gap at least 20 times higher than the gap in the light green counties.

Exhibit 1-A: Base-case Broadband Availability Gap—Cash Flows Associated With Investment Gap to Universal Broadband Availability[1]

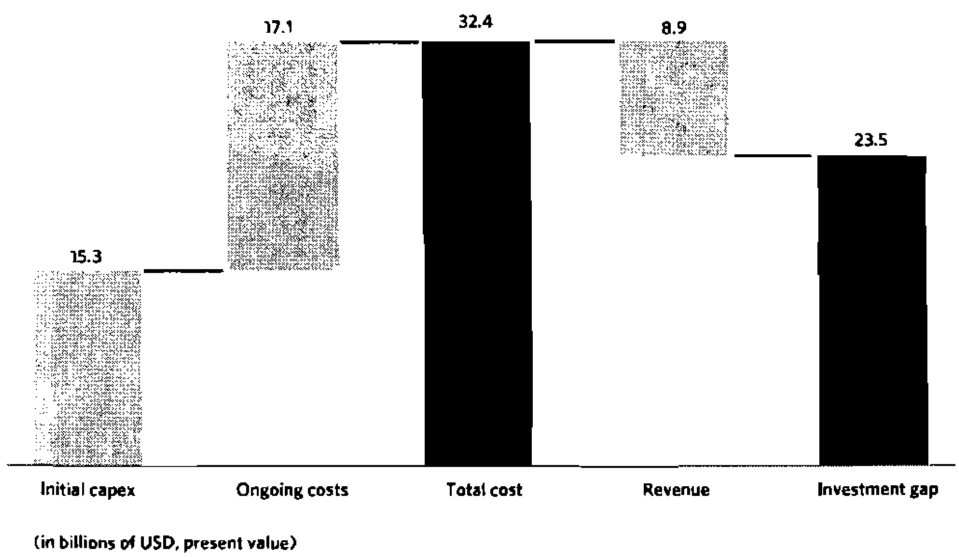
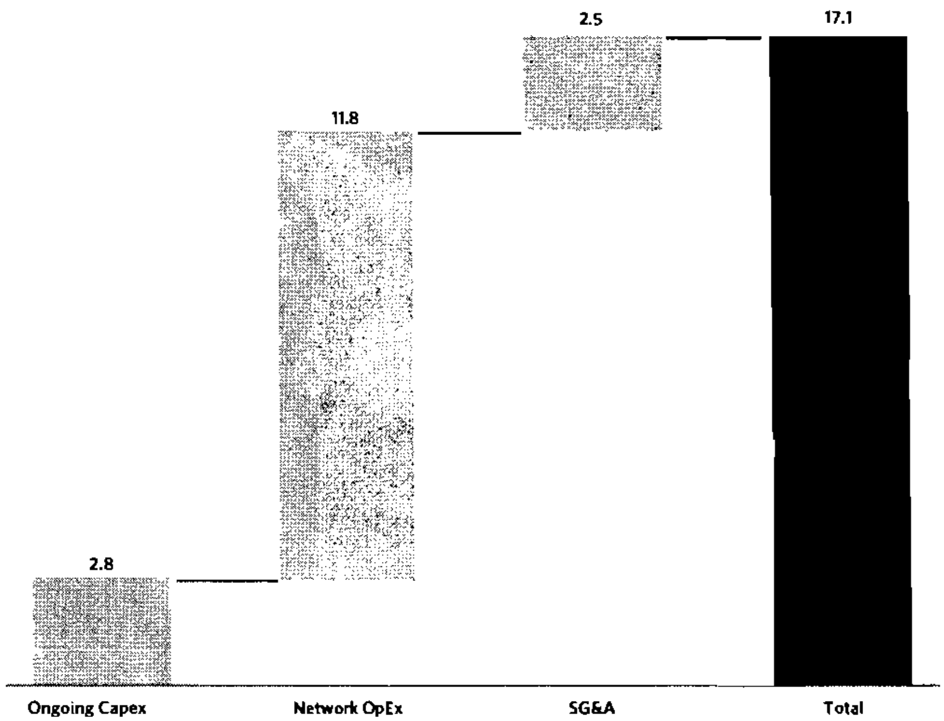
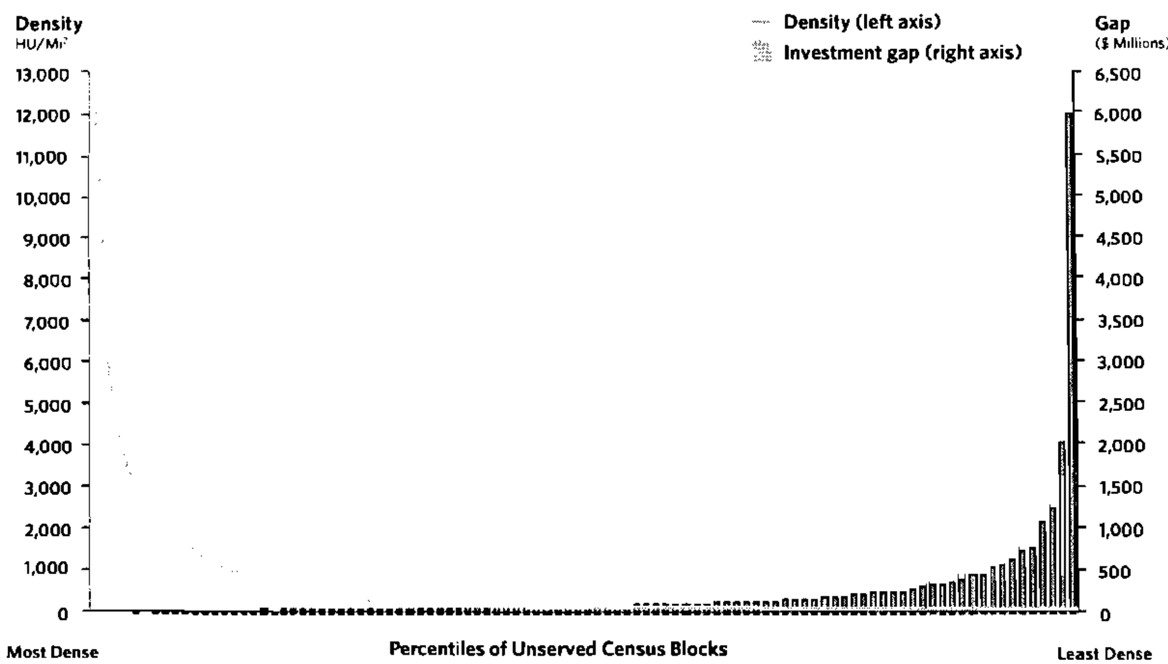


Exhibit 1-B:
Breakout of Ongoing Costs by Category



(in billions of USD, present value)
Numbers do not sum due to rounding.

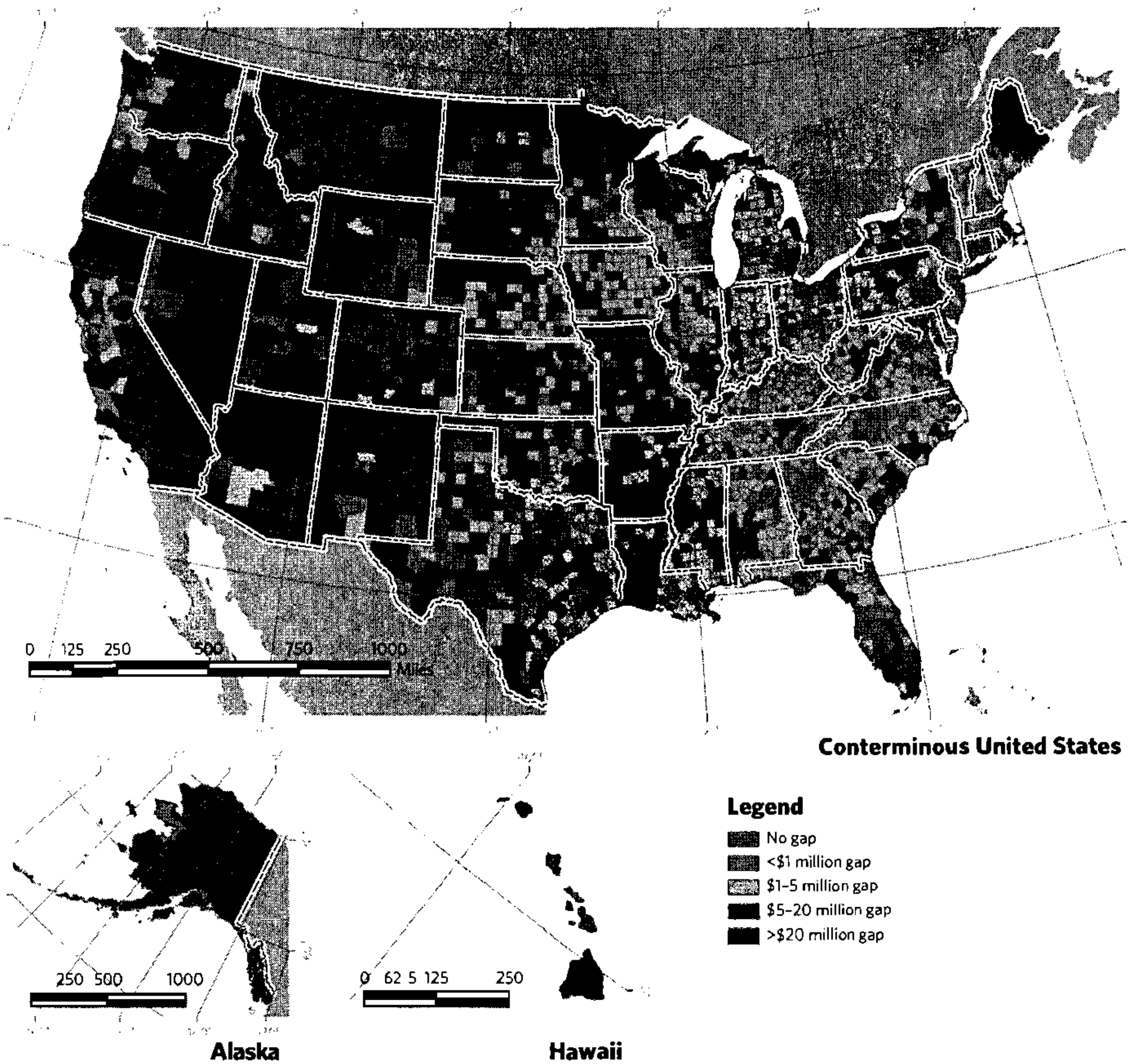
Exhibit 1-C:
Gap by Census Blocks Ordered by Population density



(in millions of USD, present value)

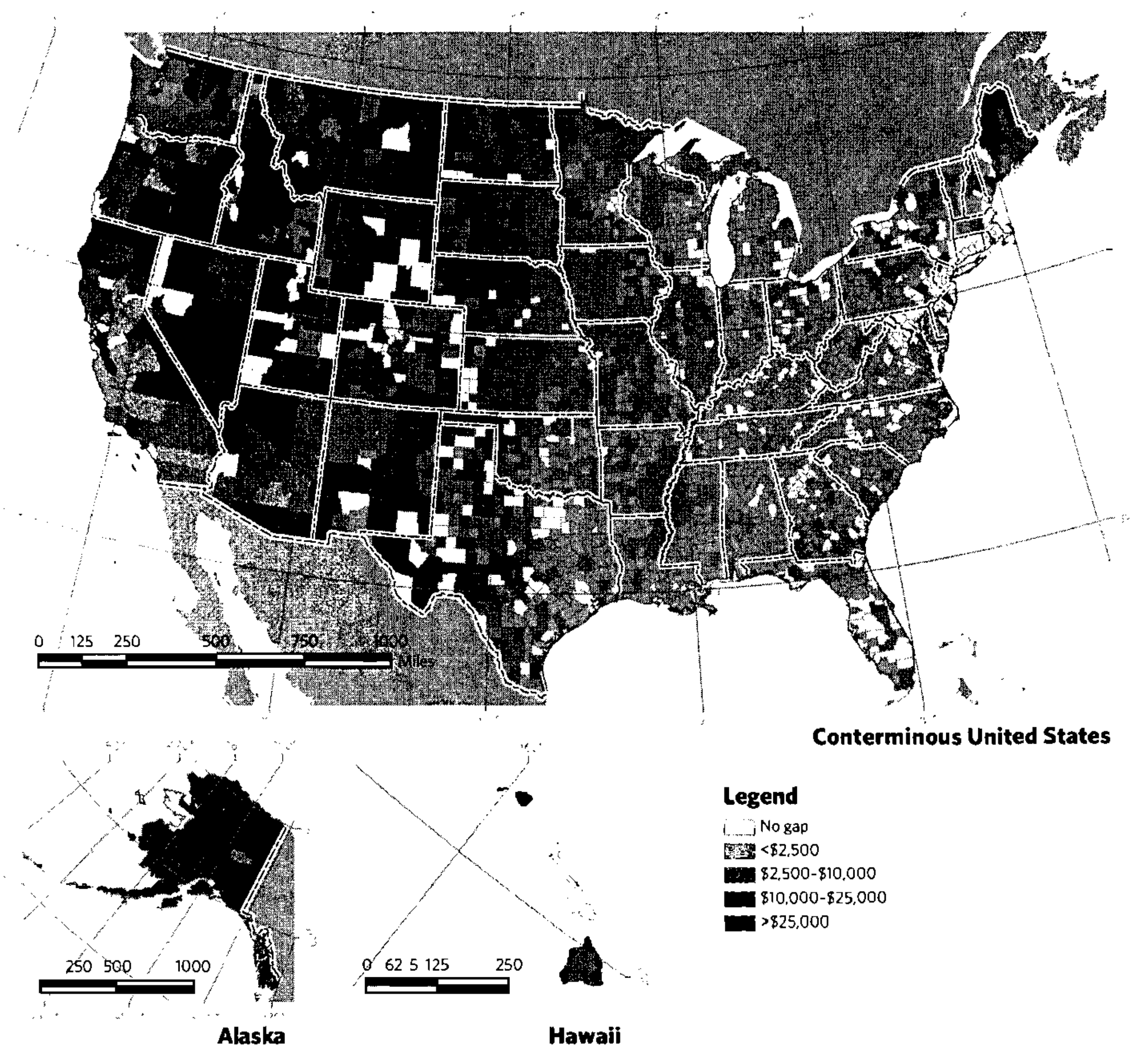
However, the total gap per county tells only part of the story. High county-level gaps can be driven by large numbers of relatively low-gap housing units and/or by small numbers of very high-gap housing units. Examining the gap per housing unit, as shown in Exhibit 1-E, highlights counties where the average gap per home is particularly high. This calculation simply takes the total gap in each county as described above, and divides by the number of unserved housing units in that county. The dark blue counties have a gap per home at least 10 times higher than the gap per home in the green counties.

Exhibit 1-D:
Broadband Investment Gap per County



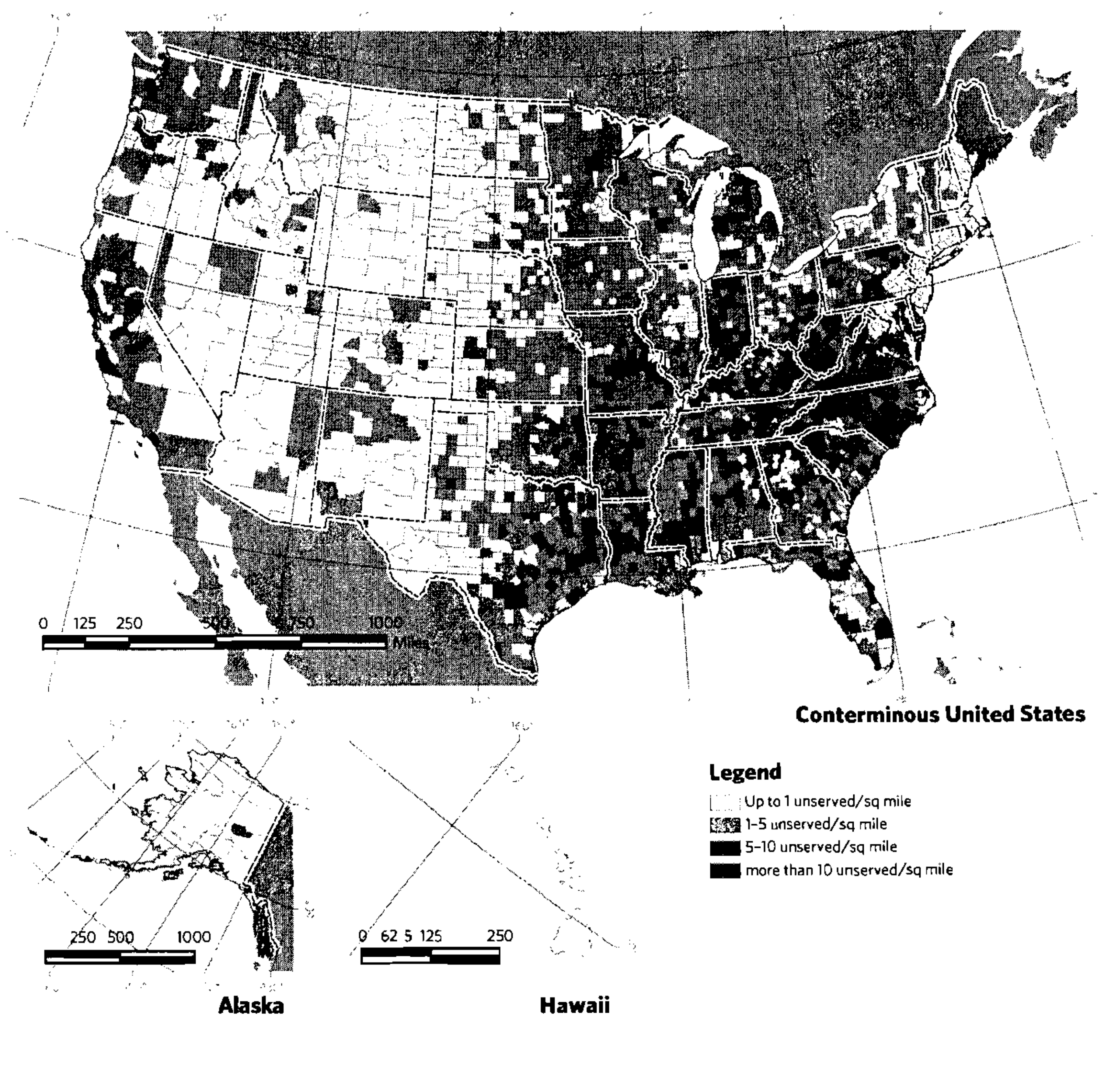
As one might expect, one of the major drivers of cost, and consequently the gap, is the density of unserved housing units (i.e., the number of unserved housing units per square mile, averaged across each county). Areas with higher density as shown in Exhibit 1-F generally have lower gaps per housing unit; note the correlation between low densities in Exhibit 1-F with higher gap per housing unit in Exhibit 1-E. Although density is not the only driver of gap, it is a significant one.

Exhibit 1-E:
Broadband Investment Gap per Housing Unit in Each County



In some areas, the gap exceeds the initial capex required to build out the area. These areas have ongoing costs that are in excess of their revenue—meaning even a network with construction fully subsidized by public funds will not be able to operate profitably. Exhibit 1-G shows the gap for each county, highlighting those where the gap is larger than the initial capex (i.e., markets that require ongoing support), colored in light blue. Areas that require ongoing support generally have larger gaps.

Exhibit 1-F:
Density of Unserved Housing Units per Square Mile



The map in Exhibit 1-H shows the distribution of counties requiring ongoing support across the country. Ongoing support is the monthly annuity required per unserved housing unit to offset ongoing losses (i.e., the amount by which ongoing costs exceed revenues, assuming the network build out is fully subsidized). The darkest colors indicate areas where the highest levels of ongoing support are needed; counties shaded in pink will not need ongoing support.

In Exhibit 1-I, areas in blue are more economic to serve with wireless, and areas in red are cheaper to serve with DSL. For each, darker colors indicate counties with a higher gap per unserved housing unit. This technology comparison is made at the county level, not at a more granular level (See Chapter 3).

Wireline tends to be cheaper in low-density areas (compare Exhibit 1-I with Exhibit 1-F), particularly where terrain drives the need for smaller cell sites that drive up the cost of wireless (see Chapter 4 on wireless technology).

To establish the $23.5 billion gap, it is necessary to make a determination as to which last mile technology is likely to be least expensive given existing infrastructure, density, terrain and other factors. These estimates notwithstanding, this approach and the NBP are technologically neutral: These estimates do ***not*** reflect choices ***or*** recommendations that a particular last mile technology be utilized in any given area. Note, that as described later in this section in "**Creating the base-case scenario and output**," the focus in this analysis is on 12,000-foot-loop DSL and fixed wireless.

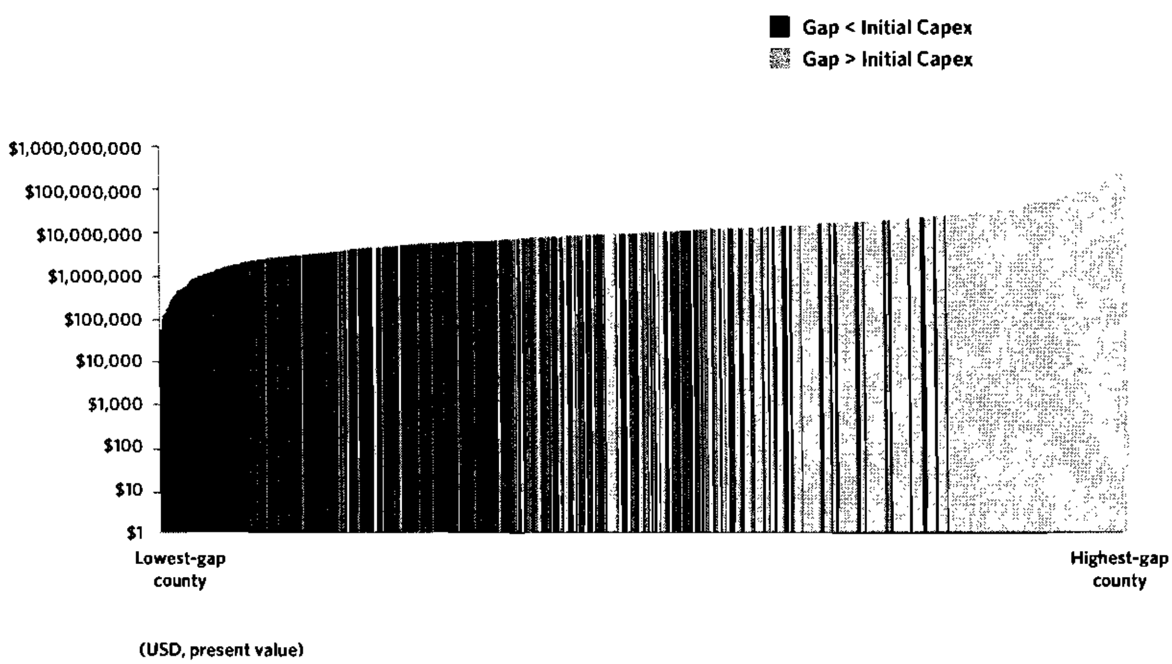
The map is somewhat misleading about the number of unserved housing units where wireline service is cheaper. In fact, while 42% of the geographic area is covered by counties where wired service has a lower gap, only 15% of counties with only 10% of the unserved housing units are in these areas; see Exhibit 1-J. Over time, these figures, which are based on the calculation of the investment gap for different technologies, may over- or under-estimate the role of any technology for a number of reasons. End-user behavior, specifically take rates or revenue per user, could differ from assumptions made in the model (see Chapter 3). In addition, the capabilities of different technologies could improve more or less quickly than assumed, or their costs could differ from what is modeled (see Chapter 4 for detail about capabilities and costs of different technologies). Finally, the impact of the disbursement mechanisms on individual service providers is impossible to include in these calculations.

The assumptions that underlie each of these calculations, and the method by which these technologies' costs are combined to reach the $23.5 billion gap, are discussed across the remainder of this document.

CREATING THE BASE-CASE SCENARIO AND OUTPUT

The base-case outputs, including the $23.5 billion gap, represent the shortfall of a particular combination of technologies across all unserved geographies. Since a single model run provides information about a single technology with a single set of assumptions, combining calculations for different technologies

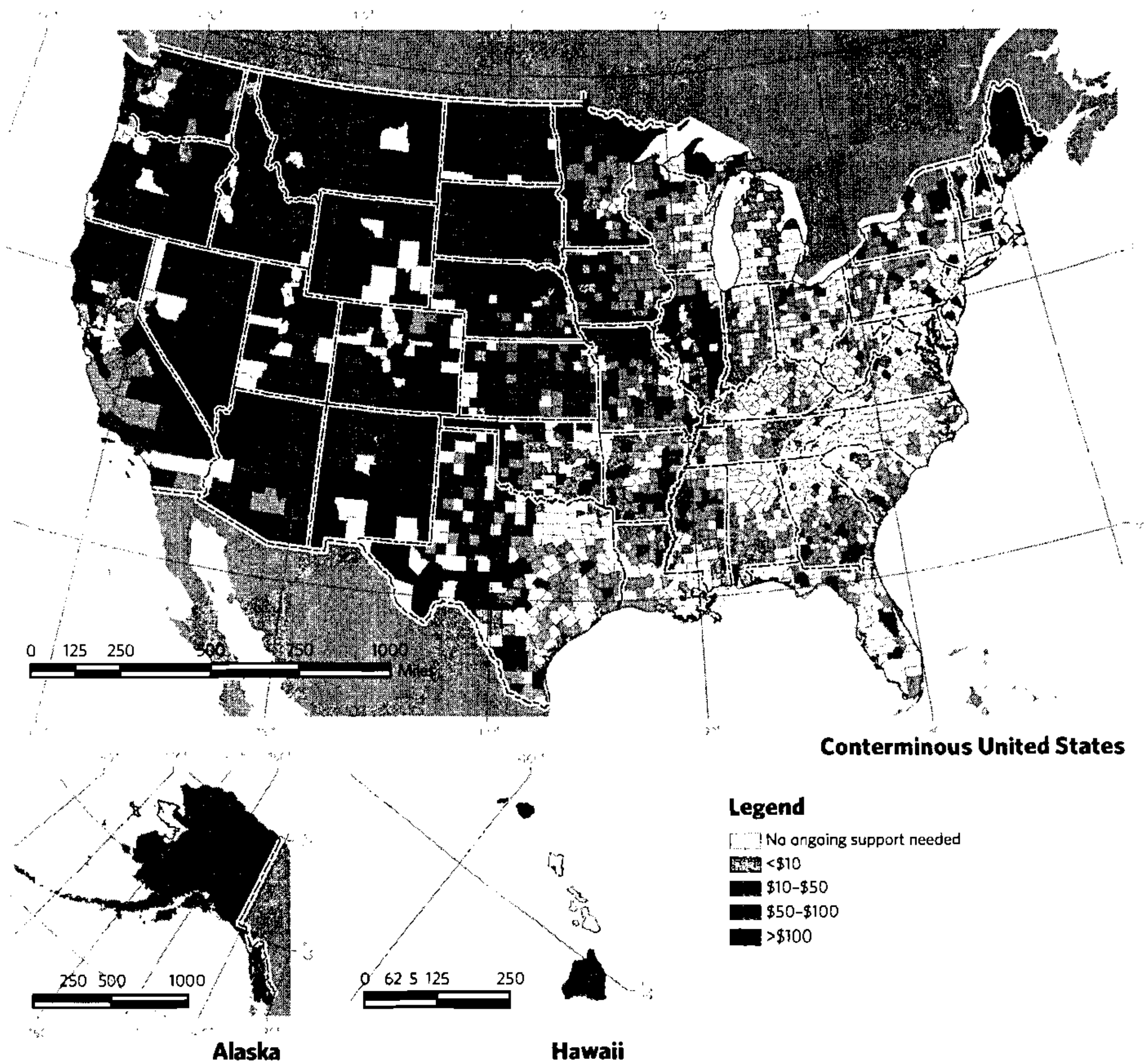
Exhibit 1-G: Broadband Investment Gap, by County



requires multiple model runs. This section describes the various models run as well as the manual post-processing required to create the single base case of $23.5 billion. Post processing of this type is required for each of the different scenarios and sensitivities shown in this document.

To create the base case, we calculate the gap for each of the two lowest-cost technologies: fixed wireless and 12,000-foot DSL (see Exhibit 4-C). Calculating the fixed wireless gap is quite complex, and requires eight different sets of model output. DSL is less complex, and requires only two sets of model

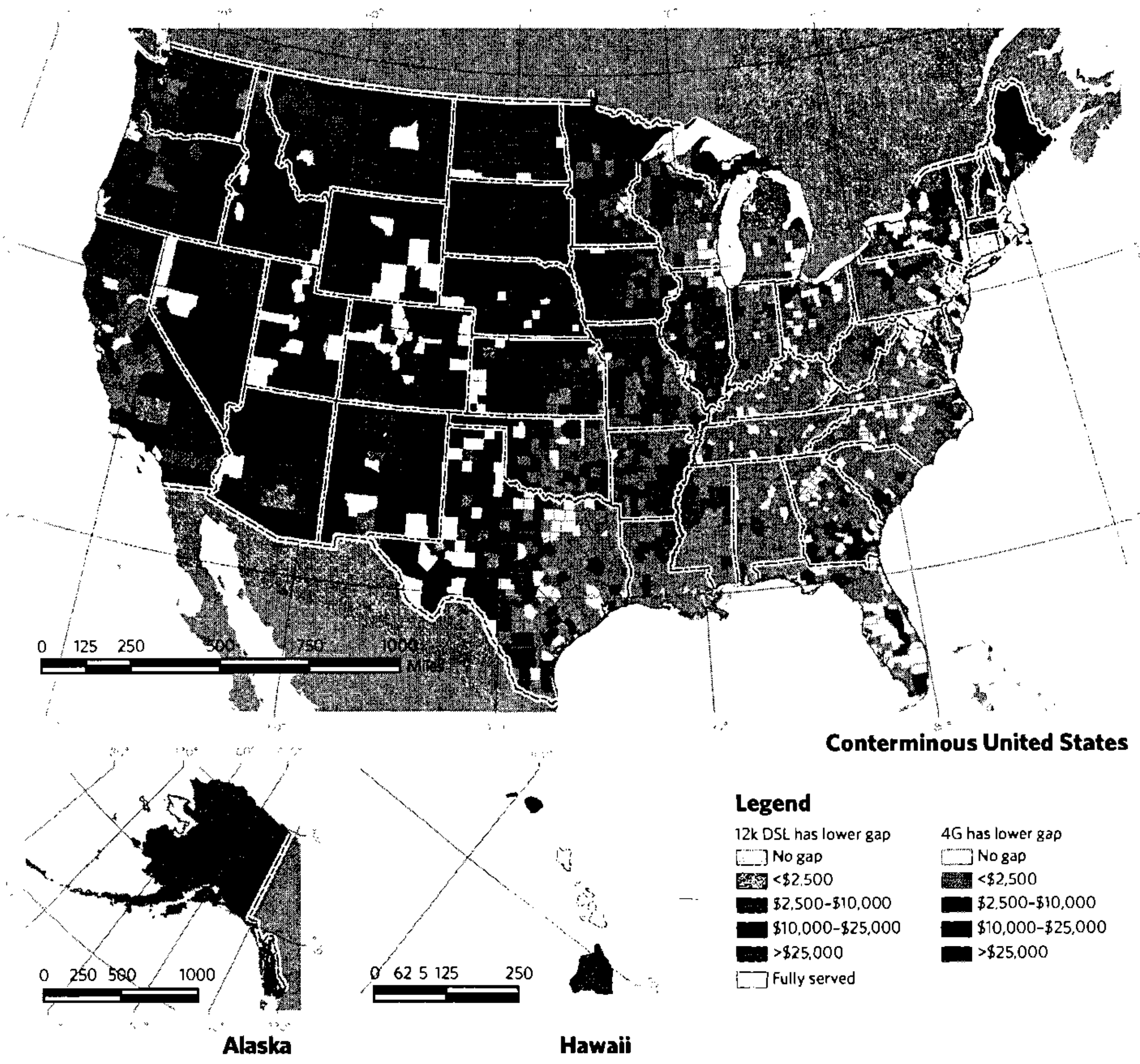
Exhibit 1-H:
Ongoing Support for Each Housing Unit per Month



output. Of course, we also calculate the gap for other technologies, which will be discussed in Chapter 4.

For wireless, we require a total of eight different runs to generate the output data and account for two different kinds of information: 1) the presence of planned commercial 4G deployments and 2) which of four different cell radii is required for each census block to provide adequate signal density given terrain-driven attenuation. The base case requires output for each combination.

Exhibit 1-I:
Investment Gap per Housing Unit by Lowest-Cost Technology for Each County



The first issue is the presence of commercial 4G deployments. A substantial fraction of the unserved are in areas we expect will be covered by commercial 4G build-outs. We treat these 4G and non-4G areas differently in our analysis to account for the costs and revenues associated with each and, consequently, need one run for each area. In 4G areas, as noted in the NBP, it is not clear whether these commercial build-outs will provide adequate service without incremental investments. The gap in these 4G areas needs to account for the fact that costs associated with the incremental investments are lower than they would be for a greenfield build. In non-4G areas, we calculate the costs for a greenfield build (note that, as will be discussed in the wireless portion of Chapter 3, we capture the cost savings available from existing cell sites, as appropriate).

Another key driver of the wireless gap is the cell radius in each area. Rather than assume a uniform cell radius across the entire country, the approach is to calculate the cost associated with different cell radii (two, three, five and eight-mile radii) and chose an "optimized" radius, which accounts for topology, for each area.

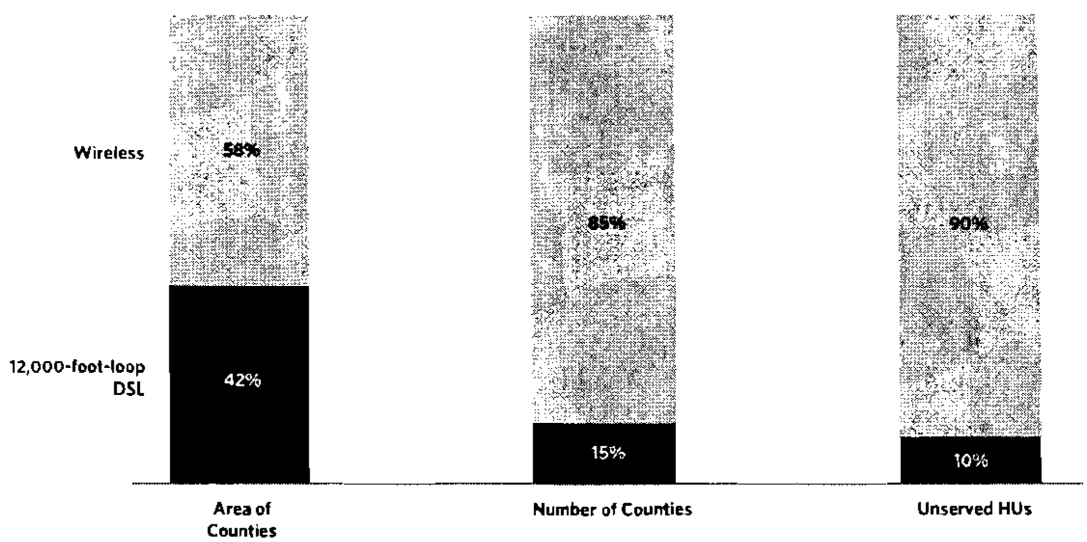
In total, then, there are eight wireless model runs: four runs (one for each radius) for the costs and gap associated with 4G areas; and four runs for the costs and gap associated with non-4G areas. For each geography (census block), we select the costs, revenues and gap from the appropriate run for each census block, depending on whether the area is in a 4G or non-4G area and what the optimized cell radius is.

The wired, 12,000-foot DSL solution is more straightforward and requires only two runs, which are required to account for the potential competitive impact of commercial 4G overlap on end-user revenue for the wired provider. While it is clear that a wireless carrier would need to make incremental investments to serve every unserved housing unit, wireless carriers will be able to serve some potentially large fraction of those within the commercial 4G footprint. Therefore, we assume that within the expected 4G footprint, DSL providers will face one fixed-broadband competitor (i.e., will split the end-user revenue with another carrier); in non-4G areas, we assume that DSL providers will not face any competition. The result is that the wired base case requires two model runs: one for 4G areas (with competition) and one for non-4G areas (without competition). The base case assumes wired solutions are all brownfield deployments where the incumbent builds out DSL service using existing twisted-pair copper.

The base case then involves calculating the lowest-cost and second-lowest-cost technology in each area. To make these comparisons at the service-area level (county level), we roll census blocks up into counties. These geographic roll-ups are made with Structured Query Language or SQL queries of the large, census-block-level output of the model and provide the essential outputs including costs, revenues and the gap for each model run or combination of model runs.

The model uses levelized costs and revenues. Levelization, often used in regulatory proceedings, calculates the annuitized equivalent—i.e., the effective annual value of cash flows—of the costs and revenues associated with building and operating a network. A levelized calculation provides a steady cash-flow stream, rather than trying to model or guess the timing of largely unpredictable yet sizable real-world payouts like those for upgrading and repairing equipment. The net present value (NPV) of a levelized cash flow is equal to the NPV of actual cash flows.

Exhibit 1-J.
Lowest Cost Technology



In order to calculate the Investment Gap as laid out in Exhibit 1-A, one need only make calculations from these market-level outputs. The three most important fields for this calculation are "contribution margin" (actually the levelized monthly gap, noting that a negative contribution margin represents a shortfall or positive gap), revenue (levelized monthly revenue) and initial capital investment.

First, determine the Investment Gap and total revenue by calculating the present value of the levelized contribution margin and revenue respectively. Second, calculate total cost by summing the present values for the investment gap and total revenue (moving from right to left in Exhibit 1-A). Third, the initial capital investment is provided in present value terms and can be taken directly from the query output. Finally, ongoing costs, which include all incremental capital expenses, operating expenses and any network residual value, are simply the difference between total cost and initial capital investment. These calculations are the same at any level of geographic aggregation, whether for the entire country or for any county.

CHAPTER 1 ENDNOTES

1 Note that this exhibit differs slightly from Exhibit 8-B of the first printing of the NBP. While the gap remains at $24 billion, the data in this paper are updated since the release of the NBP. future revisions of the NBP will include these updated data.

II. BROADBAND AVAILABILITY

Before determining the size of the Investment Gap, it is necessary to determine the current state of broadband deployment. This includes the level of service currently supported (or which will be in the near-term without government support) as well as the proximity of unserved areas to broadband infrastructure that can be leveraged to serve the area.

The complexity of this analysis is driven by the need for a very granular geographic view of the capabilities of all the major types of broadband infrastructure as they are deployed today, and as they will likely evolve over the next three to five years without additional public support.

These data are not available: There is a lack of data at the required level of granularity, both in terms of which people have access to which services, and of which people are passed by different types of physical infrastructure. To solve this problem, we combine commercial and public data on availability and infrastructure with statistical techniques to predict or infer the data needed to complete our data set.

In some cases we use broadband availability data to predict the location of broadband infrastructure, and in some cases we use the location of broadband infrastructure to predict the availability of broadband capable networks. In areas where we do not have data, we combine data from other geographies with limited physical infrastructure data in a large multi-variant regression model. We use this regression model to predict availability by speed tier and to fill in gaps, especially last mile gaps, in our infrastructure data.

Once current availability is determined, we forecast the future state by relying on recent publicly announced network build-out plans.

Where the quality of data is limited, broadband-gap calculations will be affected. For example, there are 12 wire centers in Alaska that show no population within their boundaries and an additional 18 wire centers that have no paved public-use roads (i.e., no roads other than 4-wheel-drive or forest-service roads). All 30 of these wire centers were excluded from wired broadband-gap calculations; however, all areas with population were covered by the wireless calculations. In addition, due to insufficient demographic and infrastructure data to calculate baseline availability for Puerto Rico and the U.S. Virgin Islands in the Caribbean, and Guam, American Samoa and the Northern Marianas in the Pacific, these areas are excluded from further analysis.

CURRENT STATE

Although 123 million housing units already have broadband networks available that are capable of providing service that meets the National Broadband Availability Target of at least 4 Mbps download and 1 Mbps upload, many Americans do not. Currently, 7 million housing units representing 14 million people are left without broadband that meets the National Broadband Availability Target. See Exhibit 2-A.

Exhibit 2-A: Highest Speed Capability of Available Wired Broadband Networks in the United States[1]

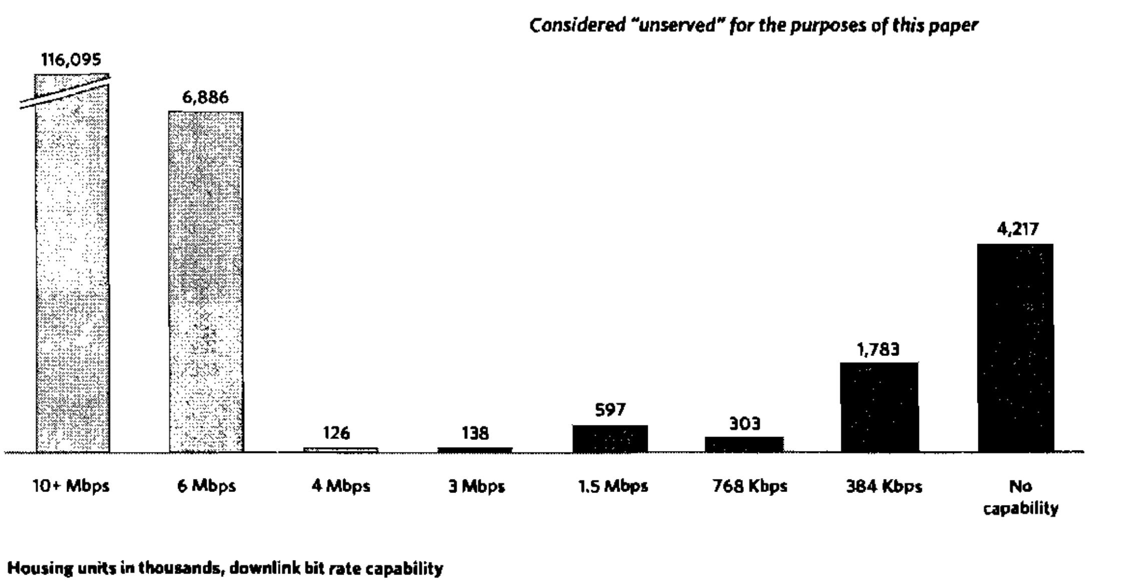
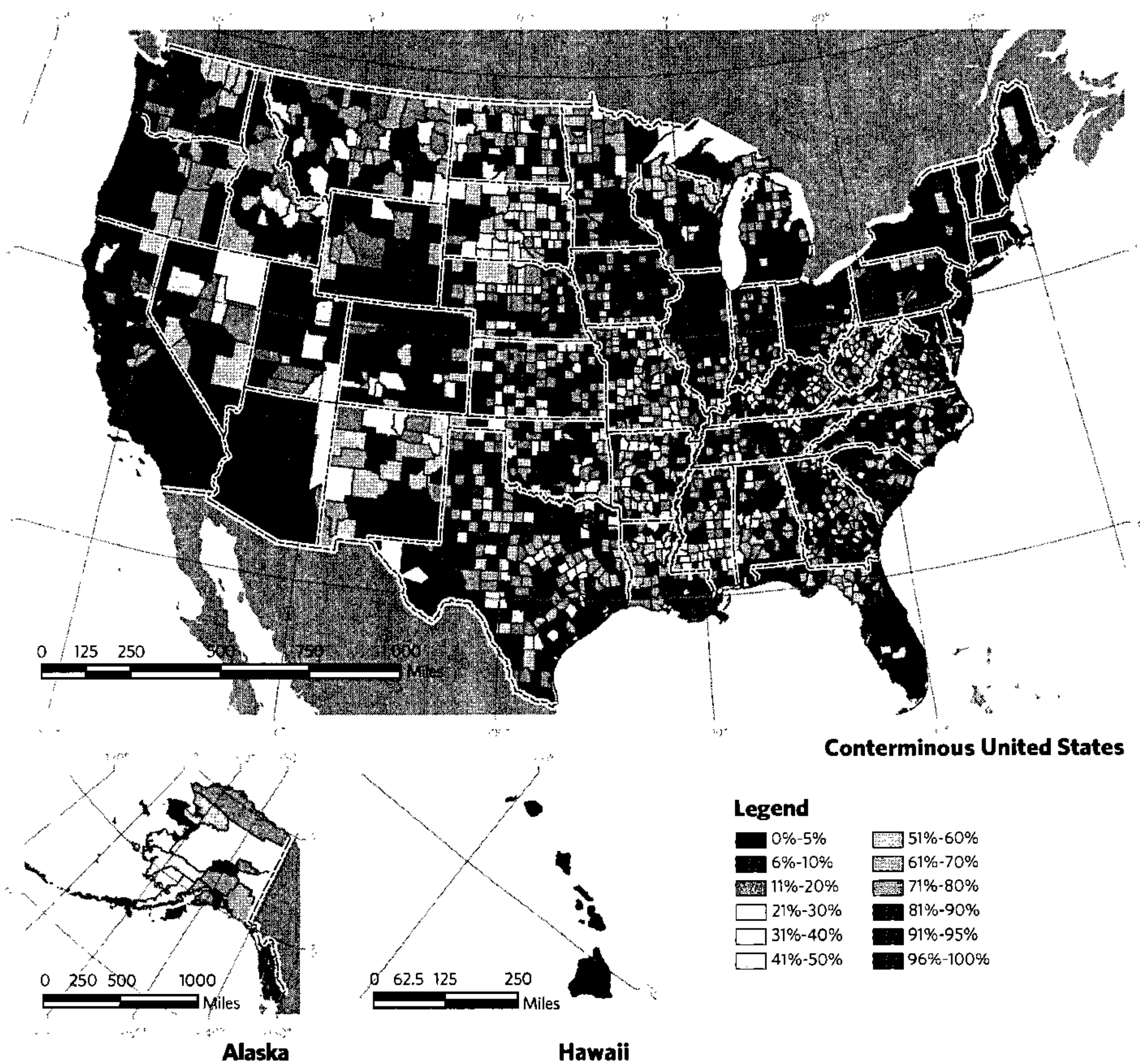


Exhibit 2-B presents the distribution of these 7 million housing units across the United States. The number of unserved housing units in each county is calculated based on the methodology described below. That number is then divided by the total number of housing units in the county to get the percentage of homes served.

Exhibit 2-B:
Availability of Broadband Networks Capable of Meeting the National Broadband Target



Purpose of the Analysis

Before determining the size of the Investment Gap, it is necessary to determine who is unserved as well as the adjacent broadband infrastructure that could be leveraged to serve them. The distance and density dependencies of both current availability and the cost of providing service to those who do not currently have it required that we take into account the geography of each unserved area at a very granular level. That, in turn, requires that we create a geographically based view of current networks and broadband capabilities in order to calculate the Investment Gap.

Our current-state model calculates the likely broadband performance from multiple technologies at the census-block level to determine the highest level of broadband service available for each census block nationwide.

This model serves two main purposes:

- It determines the number and location of housing units and businesses that do not have broadband infrastructure available that meets our performance target.
- It provides the location of network infrastructure that can be used as the foundation for building out broadband networks to these unserved housing units; these infrastructure data provide an essential input into the economic model.

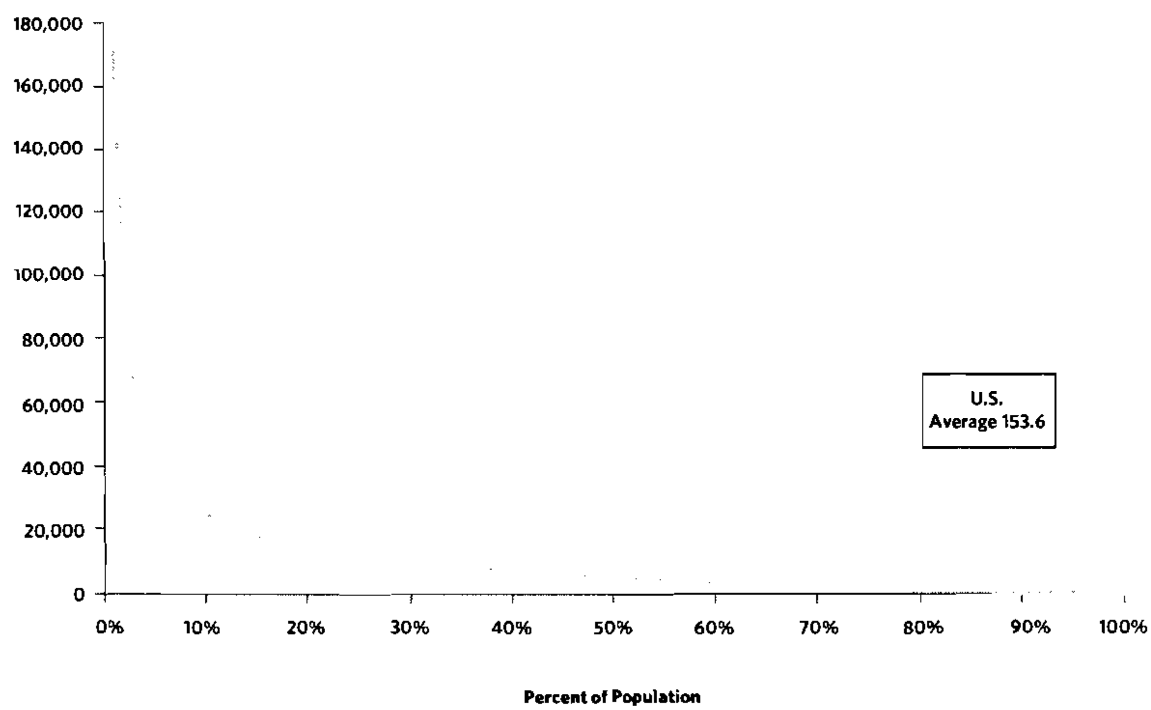
Number and location of the unserved

Once the availability of each network technology is determined at the census block level, we determine the highest speed broadband service available for each census block nationwide. Using this speed availability data and the national broadband target, we are able to determine what census blocks are currently "unserved." Then using census data for each block, we are able to determine the number of unserved housing units along with the demographic characteristics of the unserved.

Due to higher network costs per home passed, most of the unserved are located in less dense and/or rural areas. Although more sparsely populated states tend to have a larger portion of residents that are unserved, nearly every state has unserved areas. When examining the population density of the entire United States as in Exhibit 2-C, not just the unserved, one can see that a large portion of the population lives in areas of relatively low population density.

The average population density of populated census blocks in the United States is 153.6 people per square mile, though approximately three quarters of the population lives in areas of lower density. Unserved census blocks have a much lower density, with an average of only 13.8 people per square mile. The population density of the unserved follows a similar pattern to that of the country, with some areas being far more rural than others (see Exhibit 2-D). These areas of extremely low

Exhibit 2-C: Population Density of the United States, Per Square Mile of Inhabited Census Block



population density are some of the most difficult and expensive areas to serve.

The U.S. Census Bureau has categorized areas as urban areas, urban clusters and all other areas. Exhibit 2-E shows statistics of the unserved in terms of these definitions. As we can see, the deployment problem is one that predominantly exists outside of urban areas.

Since fixed broadband connects homes, not people, and most broadband networks are built along roads, either buried or on telephone/electric poles, an even more important driver of the cost to serve rural areas than population density is the number of road miles per housing unit of an area. Areas with more road miles per housing unit are even more likely to be unserved than areas of low population density. This is because the few homes in a rural area are sometimes clustered, which would decrease the number of road miles as well as the cost to serve.

The average number of road miles per housing unit in the United States is 0.07, which is much lower than the average unserved area of 0.41. But the average does not tell the whole story. A small portion of the population lives in areas with very high road-mile-to-housing-unit ratio, which tend to be the areas of the country that are unserved. Even within those unserved areas, there are portions that have an extremely high number of road miles per housing unit, which will be far more costly to serve than others. See Exhibits 2-F and 2-G.

Given the fact that the unserved are overwhelmingly in rural areas, one might expect that the unserved are in the territories of rural telecom companies. In fact, this is not the case: 52% of unserved housing units are in census blocks where one of the three Regional Bell Operating Companies, or RBOCs, (AT&T, Qwest or Verizon) is the dominant local exchange carrier; an additional 15% of unserved housing units are in census blocks

Exhibit 2-D: Population Density of the Unserved, Per Square Mile of Inhabited Census Block

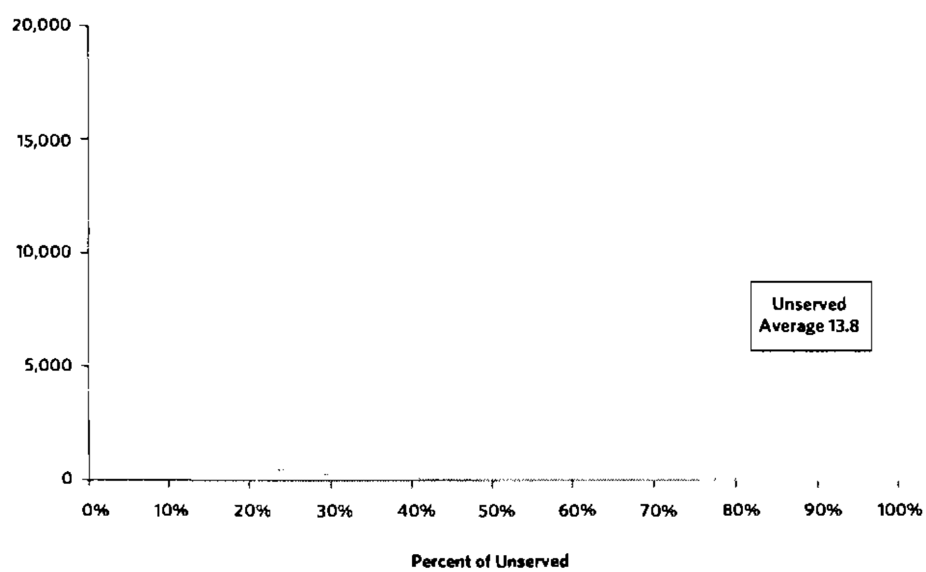


Exhibit 2-E: Statistics of Urban Areas/Clusters, and All Other Areas

Categories	AveragePeople/Sq. Mile	% of Population Unserved	# of Unserved Housing Units	Total Housing Units
Urban Areas/Clusters	2,900	1%	.7M	100M
All other areas	19	20%	6.3M	30M
Total	153.6	5%	7.0M	130M

Numbers do not sum due to rounding.

where a mid-size price-cap carrier is the dominant provider.[2] Only one-third of housing units are in census blocks where a rate-of-return carrier is the dominant provider.

Location of network infrastructure

We model each broadband network type independently to ensure a comprehensive view of infrastructure availability. Knowing where each type of network is currently deployed gives us the ability to calculate the incremental costs to upgrade the performance of an existing network as well as determine the likely location of middle and second mile fiber[3] that could be used to calculate the costs of deploying a new network.

There is a lack of comprehensive and reliable data sufficiently granular for the analysis we have described. To estimate the current state of broadband capable networks, we use the best available commercial and public data sources that meet our granularity, budget and timing requirements. We use infrastructure and speed availability data from a handful of states that were collected prior to the National Telecommunications and Information Administration (NTIA) mapping effort that is currently underway.[4] After evaluating numerous commercial data sets, we license the subset that best meets our needs.[5] We also examine Form 477 data and Form 325 data collected by the FCC but ultimately determine that these data are insufficiently granular.

The NTIA mapping effort will be complete in early 2011, and along with further revisions of the Form 477 data, they may be useful in refining our models in the future, but this will depend on the granularity of the data collected.

Network technologies modeled

The following sections include a description of our approach, data sources used, assumptions and risks for each of the three network technologies we modeled: cable, telco and wireless.

Cable

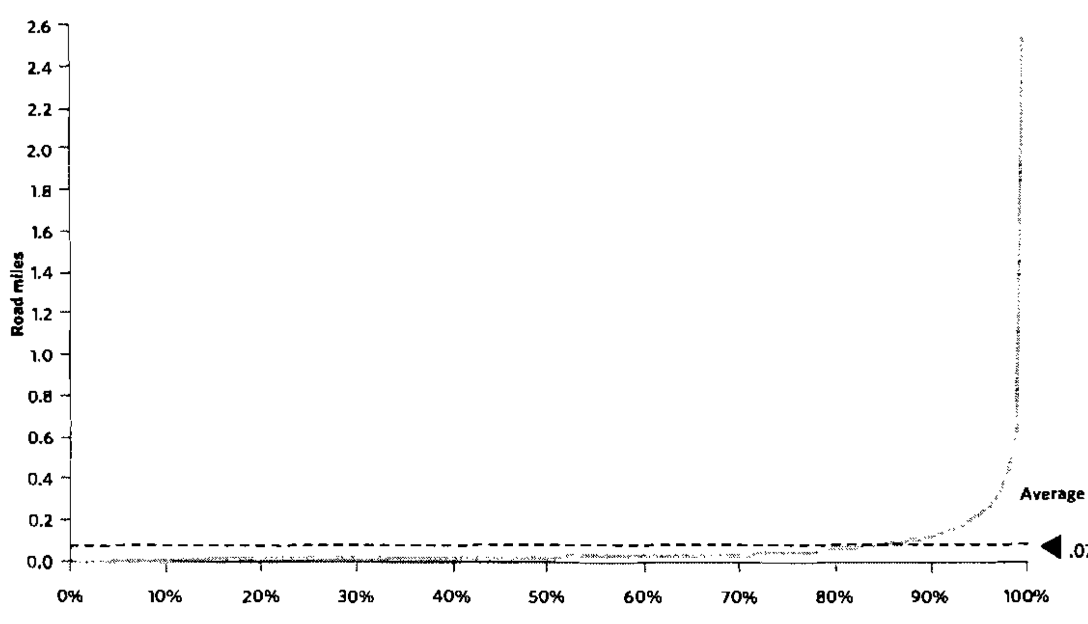
In order to determine broadband performance availability and infrastructure locations for cable networks, we use network availability data and estimated infrastructure locations based on cable engineering principles.

Data sources

In order to identify areas where cable broadband networks are located we license availability data from a commercial source[6] and collect publicly available infrastructure data from the state of Massachusetts.

We license a commercial data set from Warren Media called MediaPrints that provides data about nationwide availability of cable networks.[7] This data set includes geographic franchise boundaries as well as network capability information for cable

Exhibit 2-F: Linear Density of the United States, Ratio of Road Mile to Housing Units



Road miles per housing unit of inhabited census blocks operators nationwide. We use network capability information to exclude franchise areas where operators are still operating networks that have not been upgraded to provide two-way broadband access— i.e., we rely on a field indicating that the cable operator provides Internet services. Without detailed data on the specific services offered by each cable system, we have to make assumptions about one-way and two-way cable plant. We assume that all two-way cable plant is DOCSIS-enabled since we estimate the incremental revenue of providing broadband would likely exceed the DOCSIS upgrade costs once a cable network has been upgraded to two-way plant. We assume that the cost of upgrading areas with one-way cable to a network that supports broadband is equal to a greenfield build (i.e., we treat areas with one-way cable plant the same way we treat areas unserved by cable). We are also aware that MediaPrints may not include every cable network, but we believe the ones it excludes are smaller and are more likely to be one-way plants.

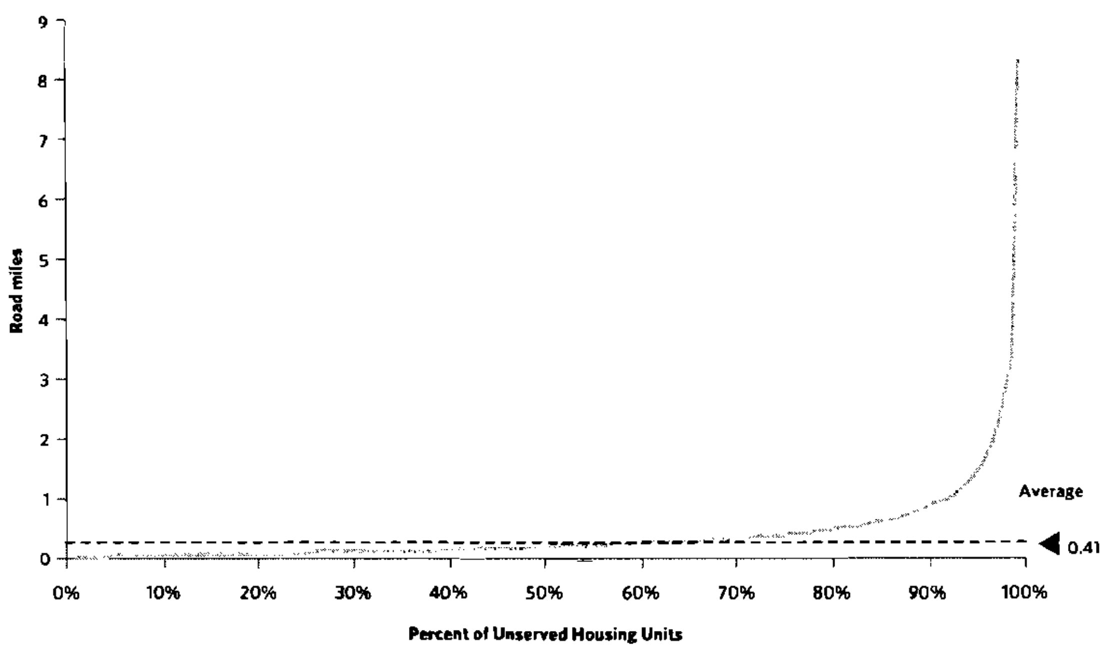
Another limitation is that the MediaPrints data do not allow us to distinguish between areas that have been upgraded from DOCSIS 2.0 to DOCSIS 3.0. In the absence of a data source that identifies the areas where DOCSIS 3.0 has been rolled out, we resort to mapping only the markets where we were able to find public announcements about DOCSIS 3.0 deployments at the time of analysis. This method understates the number of homes passed by DOCSIS 3.0 especially since the DOCSIS 3.0 rollouts proceeded quickly even as the analysis continued. But given that DOCSIS 2.0 areas exceed the broadband target speed of 4 Mbps download and 1Mbps upload, this underestimation does not affect the number of unserved or, therefore, the Investment Gap.

We are not able to acquire cable infrastructure data aggregated by any commercial or public source other than in the state of Massachusetts. These data are of limited use in the state of Massachusetts and, as we explain below, are of limited value for our nationwide analysis.

Risks

As stated previously, we may underestimate the number of housing units served in some areas since MediaPrints does not have data for every cable system, but we believe this number is small. This underestimation may be balanced by the fact that broadband availability is likely slightly overstated in the areas where MediaPrints has franchise data; this is due to the fact that cable operators do not typically build out service to every housing unit in their franchise area. We do not believe this overestimation to be significant because even large cable operators with large franchise areas tend to build out broadband to the vast majority of homes passed.[8] See Exhibit 2-H.

Exhibit 2-G: Linear Density of the Unserved, Ratio of Road Miles to Housing Units



Road-miles-per-housing-unit of uninhabited census blocks

We attempt to correct for this overestimation by comparing the MediaPrints franchise boundaries with actual cable strand maps from the state of Massachusetts.[9] In Massachusetts, operators must provide strand maps to the franchise board, which then publishes them into the public record. Unfortunately, with limited actual information available, we are unable to do a comprehensive comparison. As a result, there is not a pattern to the overestimation that could be applied nationwide.

Capabilities

As discussed in the section on hybrid fiber-coaxial (HFC) technology later in this document, we assume broadband-enabled cable networks are capable of delivering at least 10 Mbps actual download speeds, and those that have been upgraded to DOCSIS 3.0 are assumed to deliver 50 Mbps actual download.

Telco

Since we are not able to acquire a nationwide data set of either availability as a functon of broadband speed or telco infrastructure, we have to take a different approach to model telco. For telco networks we take a five-step approach to calculating availability nationwide:

1. Map availability data in areas where these data are available
2. Use telco infrastructure and engineering assumptions to estimate availability in areas where infrastructure data are available
3. Create a multivariable regression equation using demographic data (the independent variables) to predict broadband availability (the dependent variable), using states where availability data are available as sources for the regression
4. Apply regression equation to areas of the country where only demographic data exist to estimate speed availability
5. Use engineering principals and assumptions to infer infrastructure for estimated speed availability

Data sources

Although a nationwide data set of broadband availability consistent with the 4 Mbps download target is not available, there are a few states that have published availability data at different performance levels. The analysis relies on availability data from the states of California, Minnesota and Pennsylvania, and a combination of availability and infrastructure data is used from the states of Alabama and Wyoming.[10]

Some nationwide telco infrastructure data are used in conjunction with engineering principles and performance availability to more accurately estimate infrastructure locations. These data include locations of telco network nodes, such as central offices and regional tandems, from the Telcordia's LERG database, wire center boundaries from TeleAtlas and location of fiber infrastructure from GeoTel and GeoResults.

In addition to performance availability data and infrastructure data, demographic data are in the regression. These data are based on census forecasts from Geolytics for consumers and GeoResults for businesses.

We are forced to use a statistical model for telco plant because we are not able to acquire a nationwide data source of availability or telco infrastructure locations. An ideal data set for these purposes would focus on actual speed available (not on demand or subscribership), would be geographically granular (to distinguish among service speeds at longer loop lengths) and would provide information about the location of infrastructure (to feed into the economic model).

Unfortunately, no available data source meets all these requirements. Telcordia states that the CLONES database has the locations of all relevant telco infrastructure nationwide, but the FCC was not able to negotiate mutually agreeable license terms.

Data from the FCC's Form 477 are useful for many types of analysis; but, given that Form 477 data are collected at the census tract level, they are not granular enough to accurately estimate service availability and speed as noted in the September 2009 Open Commission Meeting. In the upper left

Exhibit 2-H: Cable Broadband Deployment for a Few Large MSOs as a Percentage of Homes Passed

Company	Cable Broadband Deployment (as of March 31, 2009)	Homes Passed (Millions)	Percent of Cable Homes Passed
Cablevision	100.0%	4.8	4%
Charter	94.9%	11.3	9%
Comcast	99.4%	50.6	40%
Mediacom	100.0%	2.8	2%
TWC	99.5%	26.8	21%

of Exhibit 2-I, we create an example of what perfect information on availability might look like. However, as noted in the lower left, Form 477 data provide information about the number of subscribers at a given speed, not the availability of service. Therefore, using Form 477 data to estimate availability requires making several assumptions as noted in the upper right of the exhibit. The result of these assumptions, as noted in the lower right, is that we are likely to overestimate the availability of service by relying on data collected at the census-tract level.

The ongoing efforts by states to map broadband availability, as coordinated by the NTIA as part of the Broadband Data Improvement Act[11] and funded by the Recovery Act,[12] may lead to a nationwide availability map that will be useful in this type of analysis, but the map will not be available until early 2011.

Statistical modeling where data did not exist

To estimate availability where no actual performance availability or infrastructure data exist, we create a regression equation that represents the relationship between demographic data and broadband availability data. The multivariable regression is based on more than 100 variables from population density to income levels to education levels. After determining how best to express the variables (in many cases by using their logarithms), initial models are estimated at all target speeds (ranging from 768 kbps to 6.0 Mbps) for each census block, using both forward and backward stepwise logistic regression. We use a logit regression rather than continuous so that we could use different variables and different weightings for each of the target speeds. Separate regressions are made for different speeds (768 kbps, 1.5 Mbps, 3.0 Mbps, 4.0 Mbps and 6.0 Mbps) inside and outside the cable franchise boundaries, for a total of 10 logit regressions. Accuracy rates among the 10 models were typically between 80% and 90%. Additional information on development of these statistical equations can be found in Attachment 4 of CostQuest Model Documentation.

We then use that series of statistical equations to predict broadband availability (from telco networks) at different speeds in each census block based on their demographics. This availability estimate is used to help determine what census blocks are unserved. Next, we estimate the location of network infrastructure necessary to provide that predicted level of service according to the approach outlined below. The network infrastructure location information generated by this current state model is fed into the economic model so the costs of upgrading and extending networks can be estimated accurately.

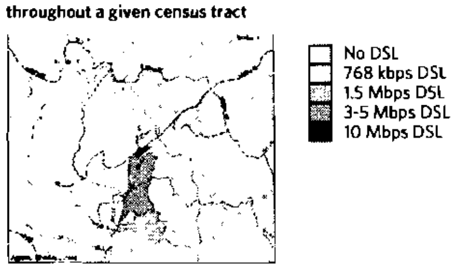
Risks

As with any statistical method, there will be errors (either over- or under-predicting the availability at a given speed) in any single, particular, small geography. However, we believe the results should be correct in aggregate. Even though we are able to achieve accuracy rates between 80% and 90% when we apply the regression to areas of known performance, the main risk in this approach is the possibility of systematic differences between the states for which we have data and the states for which we do not.

Since the statistical regression relies on a small number of states, to the extent that the tie between demographics and

Exhibit 2-I: Assumptions Required to Use Tract-Level Data Likely Overestimate Availability

It is unlikely that service is evenly distributed throughout a given census tract



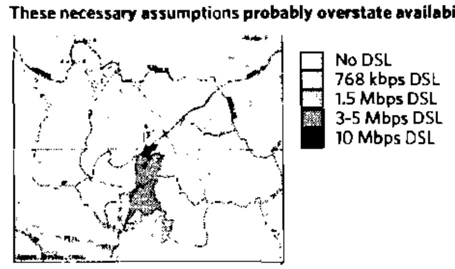
Form 477 was not designed to address this distribution question

Census tract	Housing Units	Total ADSL subs	ADSL: 768k-1.5Mbps	ADSL: 1.5-3.0Mbps	...
3749265	1,229	208	6	97	

As a result, minimal assumptions are necessary in order to make any estimate

1. Service available anywhere in a tract is available to every housing unit (HU) in that tract
2. The speed provided to the highest-speed HU in each tract is available to every HU in that tract

These necessary assumptions probably overstate availability



Sources: Census Bureau; March 2009 Form 477 data, OBI analysis network availability in the rest of the country is not the same as these states, the regression will not be accurate. The states we used in our analysis have a wide variety of rural and urban areas and have varied geographic challenges which are advantageous, but there is no way to verify our outputs without additional data.

Aligning infrastructure with availability data

We estimate the current state of broadband-capable networks using speed availability data and infrastructure data. In the areas where we have infrastructure data we use engineering assumptions to estimate speed availability. In areas where we have availability by speed we use engineering assumptions to estimate the likely location of infrastructure. In this way we are able to estimate both availability by speed and infrastructure locations nationwide.

Exhibit 2-J illustrates these two approaches. On the right-hand side is an illustration of determining speed availability from infrastructure. Imagine that data indicate the presence of a Digital Subscriber Line Access Multiplexer (DSLAM) at No. 1. Using the location of the DSLAM as a starting point, we can trace out a distance along road segments that corresponds to availability for a given speed; for 4 Mbps service, that distance is approximately 12,000 feet.

On the left-hand side is an illustration of determining infrastructure from speed availability. Imagine that we have data for the area shaded in blue that indicates it has 4 Mbps DSL. We know then that homes can be a maximum of 12,000 feet from a DSLAM. Standard engineering rules, combined with clustering and routing algorithms, allow the model to calculate the likely location of efficiently placed infrastructure. See CostQuest Model Documentation for more information.

Wireless

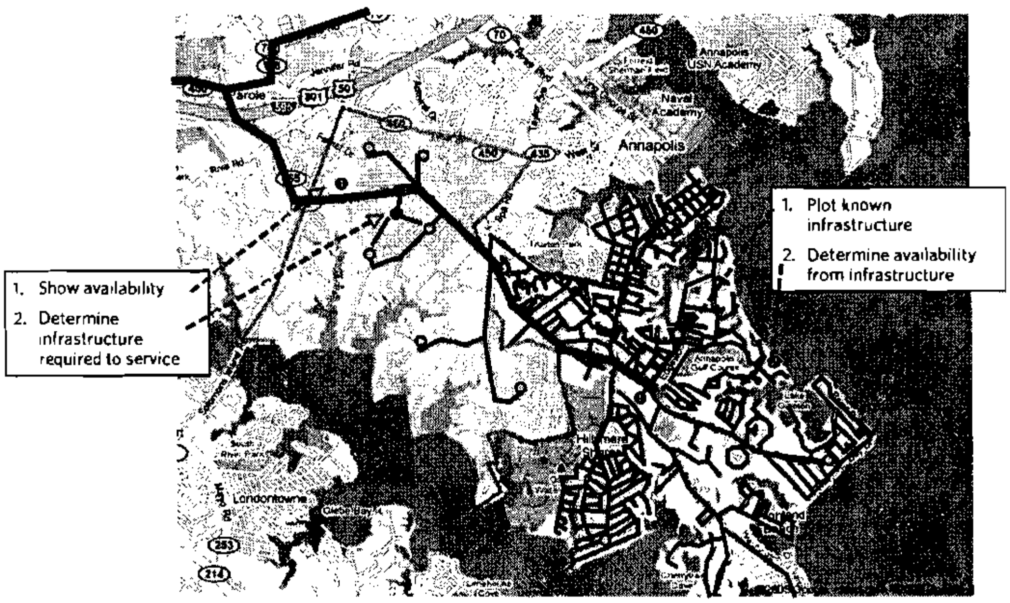
We rely on a nationwide data set of performance availability for wireless networks as well as infrastructure data in the form of tower site locations. With these two data sets we are able to estimate current availability as well as potential infrastructure locations that could be used to deploy into unserved areas. We do not create a full propagation model but rather, rely on coverage data to determine availability.

Data sources

In order to identify areas where wireless networks are located, we license a commercial data set from American Roamer. This data set provides wireless coverage by operator and by network technology deployed. The wireless technology deployed allows us to estimate the speeds available. As noted in the National Broadband Plan, American Roamer data may overstate coverage actually experienced by consumers as they rely on advertised coverage as provided by many carriers, who may all use different definitions of coverage. These definitions may differ on signal strength, bitrate or in-building coverage.

American Roamer only recently started mapping Wireless Internet Service Providers (WISP) coverage and estimates it has mapped only 20% of WISPs. We do not include WISP coverage in our model due to the current scarcity and reliability of the data.

Exhibit 2-J: Aligning Infrastructure with Availability



Like telco infrastructure, wireless infrastructure location information (typically towers) is fed into the economic model so the costs of upgrading and extending networks can be calculated accurately. We used Tower Maps data to identify the location of wireless towers in unserved areas that could be used for fixed wireless deployments.

Risks

We potentially overstate the current footprint because what is commercially available is typically based on carrier reported data, perhaps at relatively low signal strength. Overstating the current footprint could lead us to underestimate the cost of future wireless build outs to provide service to the areas currently unserved.

FUTURE STATE

We do not expect the number of unserved housing units to decline materially between now and 2013. Our analysis indicates that most unserved areas are NPV negative to serve with broadband, and so we have made the conservative assumption that there will be few new or upgrade builds in these areas. While significant investments are being made to upgrade the speed and capacity of broadband networks, those investments tend to be made in areas that are already well served. Moreover, those network upgrades are not ubiquitous throughout currently served areas. Therefore, as applications become more advanced and higher performance networks are required—i.e., if the broadband target grows significantly over time—the number of people with insufficient broadband access may actually increase.

Wired network upgrades

Both telephone and cable companies are upgrading their networks to offer higher speeds and greater-capacity networks. Cable companies are upgrading to DOCSIS 3.0, which will allow them to transfer to broadband some of the network capacity that is currently used for video. Telephone companies are extending fiber closer to end-users, in some cases all the way to the home, in order to improve the capacity and speed of the network. Besides providing a faster, higher-capacity broadband network, once fiber is within approximately 5,000 feet of the home, the network has the ability to offer multi-channel video services in addition to broadband and voice.

The Columbia Institute for Tele-Information recently released a report called "Broadband in America" in which it tried to identify as many of the major publically announced network upgrades as possible. Verizon has announced that it plans to pass 17 million homes by 2010 with its fiber-to-the-premises (FTTP) service called FiOS.[13] Many other small incumbent local exchange carriers (ILECs) also plan to aggressively build FTTP networks where it makes financial sense.[14] AT&T has announced that it will build out FTTN to 30 million homes by 2011.[15] This means that at least 50 million homes will be able to receive 20 Mbps+ broadband from their local telco within the next two years. The cable companies have also announced upgrades to DOCSIS 3.0 over the next few years with analysts predicting cable operators will have DOCSIS 3.0 covering 100% of homes passed by the end of 2013.[16] Exhibit 2-K highlights some of the major publicly announced upgrades to wired broadband networks.

As shown in Exhibit 2-L, for proven technologies, when operators publically announce plans to upgrade their network, they tend to complete those builds on time.

Using these public announcements and our current availability assessment, we create a forecast of wired broadband availability in 2013. We assume that FTTP and upgrades will take place in markets with cable that will be upgraded

Exhibit 2-K: Publicly Announced Wired Broadband Upgrades

Technology	Companies	2009	2010	2011
FTTP	• Verizon • Cincinnati Bell • Tier 3 ILECs	• All providers (17.2MM—as of Sept) • Verizon FiOS (14.5MM– as of June)	• Verizon FiOS (17MM)	
FTTN	• AT&T • Qwest	• Qwest (3MM)	• Qwest (5MM)	• AT&T U-verse (30MM)
DOCSIS 3.0	• Comcast • Cablevision • Cox • Knology • Time Warner • Charter • Mediacom • RCN	• Comcast (40MM) • Charter (St. Louis) • Mediacom (50% of footprint) • Knology (50% of footprint) • RCN (begin deployment)	• Comcast (50MM) • Cablevision (entire footprint) • Cox (entire footprint) • Time Warner (New York City) • Knology (entire footprint)	

Exhibit 2-L:
With the Exception of Satellite, Most Announced Broadband Deployments are Completed on Schedule

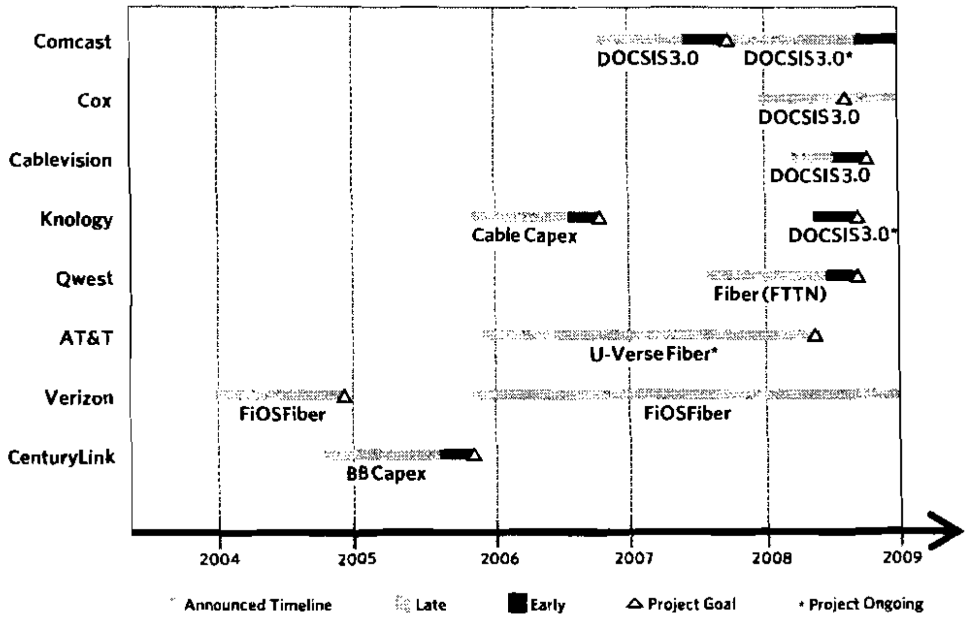
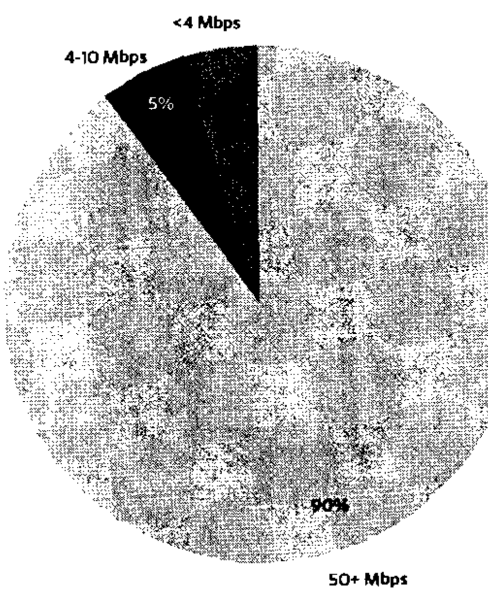


Exhibit 2-M:
Projected 2013 Availability of Broadband Capable Networks



Fastest downlink speed capability of broadband networks
Percent of U.S. population with network availability, Mbps

to DOCSIS 3.0. Therefore, as Exhibit 2-M shows, all of the announced upgrades will likely take place in areas that were already served. Without government investment, the difficult-to-reach areas will remain unserved while the rest of the country receives better broadband availability.

Wireless network upgrades

The wireless broadband networks are still in the nascent stages of development and continue to evolve rapidly with new technologies, applications and competitors.

Many operators still have significant areas covered by 2G technologies but have already announced upgrades to 4G data networks. Mobile operators are investing heavily in network upgrades in order to keep pace with exploding demand for mobile data services.

By 2013, Verizon plans to roll out Long Term Evolution (LTE) technology to its entire footprint, which covered 288 million people at the end of 2008.[17] AT&T has announced that it will undertake trials in 2010 and begin its LTE rollout in 2011. Through its partnership with Clearwire, Sprint plans to use WiMAX as its 4G technology. WiMAX has been rolled out in few markets already and Clearwire announced that it plans to cover 120 million people by the end of 2010.

For well-known technologies, when operators publically announce plans to upgrade their network, they tend to complete